REMARKS

Claims 25-26, 28, 33-36, and 42-45 are pending in the present application. By this amendment, claims 44-45 have been canceled, claims 25, 33, and 42-43 have been amended, and new claim 46 has been added. In the Office Action dated January 10, 2008, claim 43 was rejected under 35 U.S.C. § 112, ¶ 2, as being indefinite for failing to particularly point out and distinctly claim the subject matter regarded as the invention. Claims 33-36, 42, 44 and 45 were rejected under 35 U.S.C. § 102(a) as being anticipated by U.S. Patent No. 6,177,331 to Koga ("Koga"). Claims 25-26, 28 and 43, insofar as being in compliance with 35 U.S.C. § 112, were rejected under 35 U.S.C. § 103(a) as being unpatentable over Koga in view of U.S. Patent No. 6,146,970 to Witek et al. ("Witek") and/or U.S. Patent Publication No. 2001/0030367 to Noguchi et al. ("Noguchi").

The Applicants thank the Examiner for the telephone conference conducted on April 8, 2008. During the interview claim 25 was discussed. In particular, the Examiner admitted that Figure 3 of the Koga reference does not disclose that the pad layer is a different layer than the silicon nitride layer.

Regarding the 112 rejection of claim 43, claim 42, on which claim 43 depends, has been amended to state "a silicon oxide layer" and claim 43 has been amended to state "the silicon oxide layer." Therefore, this corrects the antecedent basis issue of claim 43 and the rejection should be withdrawn.

The embodiments disclosed in the specification will now be discussed in comparison to the cited references. Of course, the discussion of the disclosed embodiments, and the discussion of the differences between the disclosed embodiments and the cited references, does not define the scope or interpretation of any of the claims. Instead, such discussed differences merely help the Examiner appreciate important claim distinctions discussed thereafter.

The present application is directed to a structure and method for filling an opening in a semiconductor structure that is less susceptible to the formation of voids. An embodiment of the present application is directed to a semiconductor structure comprising a pad oxide layer formed on a substrate, a silicon nitride layer formed on the pad layer, and a mask layer formed on the silicon nitride layer. Each of the layers above the substrate has an opening above a trench

in the substrate. The opening in the silicon nitride layer has a tapered shape, and the opening in the mask layer is less than one of the dimensions from the tapered silicon nitride layer. The pad layer that is formed on the substrate is a separate layer from the silicon nitride layer. In some embodiments, the pad layer protects the substrate from damage that may occur during the forming of the semiconductor structure. Additionally, the pad layer promotes adhesion of the silicon nitride layer.

The Koga reference is also directed to a method of filling a trench with insulating material that is less susceptible to forming voids. The Koga reference discloses in Figure 1d a semiconductor structure comprising a silicon dioxide layer 102 formed on a substrate 101 and a silicon nitride layer 103 having tapered openings 110 formed on the silicon dioxide layer 102. None of the Figures 1a-1g disclose or fairly suggest a mask layer formed on the silicon nitride layer 103 having an opening with a dimension that is less than the larger opening from the tapered opening 110 in the silicon dioxide layer.

However, Figures 3c and 3d show a semiconductor structure having a mask layer 106 on top of a silicon dioxide layering where the mask layer 106 has an opening with a dimension that is less than a larger opening from a tapered opening in a silicon dioxide layer 108. However, the mask layer 106 is silicon nitride and the tapered layer 108 is silicon dioxide. Figures 3a-3g do not show the silicon nitride having tapered openings. The Examiner, however, contends that the silicon nitride layer and the silicon dioxide layer could be switched. However, the Koga reference teaches away from such a configuration. In particular, the Koga reference states that the benefit of the third example is that the tapered silicon dioxide film is formed by an isotropic wet etch step that makes the taper process easy. Column 7, lines 49-51. In contrast, the tapering of the silicon nitride film 103 in Figure 1 was formed by an etch step using a physical sputtering process, which is much more complicated than a mere wet etch step.

Additionally, if the silicon nitride layer was switched with the silicon dioxide layer, the semiconductor structure in Figure 3 would have to go through three processing steps rather than just two processing steps to remove the silicon nitride layer 108 and silicon dioxide layer 112. For instance, Figure 1 discloses silicon nitride being the tapered film. In order to remove the silicon dioxide film 112 and the silicon nitride layer 110, the structure first goes through a CMP polish. Then to remove the remaining portion of the silicon nitride film 110 the

structure is wet etched by a *heated* aqueous hydrofluoric acid solution and then wet etched by a separate aqueous hydrofluoric acid solution to remove the silicon dioxide layer 112 and 102. See column 5, lines 55-59 in reference to Figure 1. In contrast, the semiconductor structure of Figure 3 only needs to go through two processing steps to remove the second silicon dioxide film 112 and the first tapered silicon dioxide film 108. The first step is a CMP step similar to that in Figure 1 and the second step is a single wet etch step comprising an aqueous phosphoric acid solution, rather than the two wet etch steps discussed above. See, column 7, lines 41-48.

Furthermore, the method used in Figure 1 indicates to persons having ordinary skill in the art, that a mask layer is not needed above a tapered silicon nitride layer indicating that there would not be a reason to switch the layers in Figure 3. Therefore, the Koga reference does not disclose, and in fact teaches away from, the silicon nitride layer and the silicon dioxide layers being switched. Finally and as agreed by the Examiner in the telephone interview, the semiconductor structure in Figures 3a-3g do not disclose or fairly suggest a pad layer disposed on the substrate being a different layer or material than the tapered silicon dioxide film 108.

The Examiner cited the Witek and Noguchi references for teaching that silicon nitride is often used as an etch stopper. However, even assuming that this is correct, neither the Witek nor Noguchi references make up for the fact that the Koga reference teaches away from switching the silicon nitride layer with the silicon dioxide layer.

Turning now to the claims, the patentably distinct differences between the cited references and the claim language will be specifically pointed out. Claim 25 recites, in part, a layer of silicon nitride formed over the substrate and having a tapered opening therethrough over the trench, the tapered opening having a first dimension on a first surface of the silicon nitride layer adjacent to the trench less than a second dimension on a second surface of the silicon nitride layer opposite the first surface of the silicon nitride layer, the first dimension being substantially equal a width of the trench proximate the first surface. The Koga, Witek and the Noguchi references do not disclose or fairly suggest the above limitation. Rather, the Koga reference teaches away from such a configuration. As alluded to above, the Koga reference teaches tapering the silicon dioxide film because it is easy to taper by a wet etch step. Furthermore, removing the first silicon dioxide film 108 and second silicon dioxide film 112 may be done in only two processing steps rather than three processing steps if the silicon dioxide

film were switched with the silicon nitride film as suggested by the Examiner. The Witek and the Noguchi references fail to make up for what is taught away in the Koga reference. Therefore, claim 25 is allowable over the Koga, Witek, and Noguchi references.

Claims 33 and 42 were rejected under Figure 1, however, claim 33 and 42 have been amended to recite a mask layer and a silicon oxide layer, respectively, where the mask layer or the silicon oxide layer is formed over the silicon nitride layer, where the mask layer or the silicon oxide layer has an opening therethrough positioned over the trench and having a dimension less than the second dimension of the opening of the first layer of silicon nitride. Because this limitation is not in Figure 1 and because the Examiner rejected claim 25 in reference to Figure 3, the remaining remarks regarding claim 33 and 42 will be directed to Figure 3.

Similarly, amended claim 33 recites, in part, a first layer of a silicon nitride material formed over the substrate and having a lower surface proximate to the substrate and an upper surface opposite of the lower surface, and further having an opening therethrough over the trench, the opening having a first dimension along the lower surface and a second dimension along the upper surface greater than the first dimension, the first dimension being substantially equal a width of the trench proximate the lower surface. Therefore, claim 33 is allowable for at least the same reasons claim 25 is allowable. Additionally, claim 33 recites, in part, a pad layer disposed between the substrate and the first layer of silicon nitride material, the pad layer being of a different material than the silicon nitride layer. As agreed to by the Examiner, Figure 3 does not disclose a pad layer being different from the silicon dioxide layer. Therefore, claim 33 is allowable over the Koga reference.

Amended claim 42 recites, in part, a layer of silicon nitride formed over the substrate and having a tapered opening therethrough over the trench, the tapered opening having a first dimension on a first side adjacent the trench less than a second dimension on a second side of the first insulating layer opposite the first side and a pad layer disposed between the layer of silicon nitride and the substrate, the pad layer being of a different material than the silicon nitride layer. Therefore claim 42 is allowable for at least the same reasons that claim 25 and 33 are allowable.

Claims depending from claim 25, 33, and 42 are also allowable due to depending from an allowable base claim and further in view of the additional limitations recited in the dependent claims.

Claim 25 was amended merely to resolve a typographical error.

All of the claims remaining in the application are clearly allowable. Favorable consideration and a timely Notice of Allowance are earnestly solicited.

Respectfully submitted,

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